5.0 DOCUMENTATION ASSESSMENT

This portion of ASP-I provides an assessment of the completeness of available model documentation and the compliance of each component to a set of proposed, tailored standards; recommendations for bringing the documentation into compliance with those standards; and implications of the current state of documentation on model use and verification and validation (V&V) efforts. This assessment provides the model manager with specific information on how the documents can be improved and also provides the model user with a quick description of the adequacy of the documentation set.

A study sponsored by the SMART Project identified the documentation necessary to support the verification of mature models. The results of that study are published in a report entitled *Software Verification Requirements Study (SVRS) for the SMART Project* [Ref. 8]. The SVRS describes the minimum set of documents and content standards required to assist a potential user to evaluate the suitability of an existing model for a specific purpose and ensure that it has been rigorously verified against known standards and procedures. These documents should allow the potential user to: have confidence that the model is accurate; decide if the model simulates the problem(s) of concern; have sufficient information to install and run the program(s); modify the model to work on the target platform (if necessary); understand all inputs and outputs; and fix problems during model use, either due to runtime errors, incorrect input, or incorrect program operation.

The document used in formulating these recommendations was the Defense System Software Development, DOD-STD-2167A, which established requirements to be met by government contractors for the acquisition, development, or support of software systems. This document grew out of the need to standardize and manage the development of computer software in the DoD community and it includes requirements for software documentation. After an extensive search for, and review of, government requirements and guidelines, the following documents were identified as the minimum set necessary for mature model verification: Software User's Manual (SUM), Software Programmer's Manual (SPM), Software Analyst's Manual (SAM), Software Design Document (SDD), and Software Verification Report (SVR).

The SUM and SPM formats described in DOD-STD-2167A were tailored for digital simulation models. The SAM is not addressed by 2167A; therefore, its format was generated after a review of other sources. Electronic Combat Digital Evaluation System (ECDES) Model Documentation and Programming Guidelines were also used as guidelines for implementing DOD-STD-2167A. The existing SAMs for ESAMS, ALARM, and RADGUNS were also used to provide guidance for the recommendations. The SDD and SVR typically do not exist for mature models. However, SMART has sponsored tasks to support the development of equivalent documents for several models: the Conceptual Model Specifications (CMSs) and Verification Reports (VRs).

BRAWLER Version 6.15 was found to have three of the recommended documents: a SUM [Ref. 1], a SPM [Ref. 2], and a SAM [Ref. 3]. The assessment revealed that BRAWLER is a mature model that has evolved during the past 20 years. Like many models with similar histories, an SDD was never written. A conclusion of the assessment is that a SDD is necessary to conduct verification of the model since an SDD sets forth the requirements to be verified as being correctly implemented. The documentation assessment for BRAWLER focuses on the SUM, SPM, and SAM; portions of other BRAWLER documentation (Refs. [4] through [7]) will be recommended to be incorporated in the three

standard documents as applicable. Table 5-1 summarizes the assessment of existing BRAWLER documentation.

The documentation assessment for BRAWLER focuses on the SUM, SPM, and SAM; A proprietary software package produced by the BRAWLER developer, Decision-Science Applications, Inc. (DSA), also was evaluated for applicability to the standard SUM, SPM, and SAM. This package is called DSA_ENVIRONMENT (DSA_ENVIRONMENT is copyrighted by DSA Incorporated) Development Environment. The environment provides configuration control capabilities during software development of a single program by several individuals; it has several utility routines that provide maintenance features to assist in developing and testing code. Many of these features are available as UNIX script files. Some information available when executing script files can help to efficiently produce portions of a standard SPM. The DSA_ENVIRONMENT software was executed to evaluate the script files. Script file availability to automate the compilation of SPM-applicable information will be acknowledged in the assessment of the current SPM. Specific script descriptions are provided in the DSA_ENVIRONMENT User's Manual [Ref. 7].

Some information from the user's manual for version 6.15 has been made available in magnetic media format. It is distributed (for the first time) with BRAWLER Version 6.2 as an "On-line documentation feature". However, another proprietary software package call FrameViewer® is needed to utilize the on-line documentation. The reference version evaluated in this DAR is BRAWLER Version 6.15. The on-line information was evaluated for applicability to version 6.15. Also, bugs and errors in the new on-line feature are described in the assessments of this report. These bugs and errors generally are related to cross-referencing and hypertext link deficiencies which encompass both version 6.15 and 6.2. The numerous deficiencies are not itemized in this report. Rather, deficiencies are categorized, and recommended procedures to correct the categories are provided.

TABLE 5-1. Documentation Assessment Summary for BRAWLER.

Characteristic	SUM	SPM	SAM
Publication Date	May 1993	December 1992	May 1993
Applicability	Version 6.15	Version 6.14	Version 6.15
Completeness	Adequate (Complete except for an adequate list of error messages, detailed discussion of assumptions and limitations, and detailed file format descriptions)	Adequate (Complete except for error detection and diagnostics, module descriptions, high-level/detailed call trees, dictionary of variables, discussion of global variables)	Adequate (Complete except for adequate detail in equation and algorithm description, subfunction input and output, and detailed assumptions and limitations)
Compliance	Complies (Except for some minor modifications)	Complies (Except for some minor modifications)	Complies (Except for some minor modifications)

Notes: The characteristics and adequacy of the model documentation are summarized in the above table using the following criteria:

* Completeness — The completeness of the documentation is stated as "Complete," "Adequate," (the implication being incomplete, but adequate), "Inadequate," or "Nonexistent."
* Compliance — The compliance of the documentation with referenced standards is stated as "Complies" or "Does Not Comply."
* Applicability — The version of the model the documentation represents is stated as "Current" (the latest version) or "Version (n.n.n)."

5.1 COMPLETENESS

Tables 5-2 through 5-4 provide summaries of the completeness of the SUM, SPM, and SAM detailed by elements required for each section. Summing the results, out of a total of 43 content elements, 16 were included and complete, 23 were included but partially complete, and 4 were not included.

5.1.1 Completeness of Software User's Manual

The BRAWLER SUM has most of the information required for a standard SUM. Most of the information for the standard SUM can be copied from the existing BRAWLER Version 6.15 SUM; although, reformatting and content additions are required for a standard SUM. The most serious deficiencies are the lack of an adequate list of error messages, a comprehensive discussion of assumptions and limitations, and detailed file format descriptions. Table 5-2 summarizes the contents of the BRAWLER SUM.

TABLE 5-2. Contents Summary of SUM for BRAWLER.

Software User's Manual	Complete
Title Page and Preliminary Information	P
1.1 Identification	P-RN
1.2 System Overview	Y-SUM, SPM, SAM, MSM
1.3 Document Overview	Y
2.0 Referenced Documents	Y
3.1 Initialization	Y- SUM, DATB
3.2 User Inputs	P
3.3 Links To Other Programs	Y- SUM, SPM
3.4 Outputs	P
4.0 Error Messages	P- SUM, SPM
5.0 Terms and Abbreviations	Y
Appendix A: Detailed Assumptions and Limitations	P- SUM, SAM, MSM

Notes:

Y	Included and Complete	SUM	Software Analyst's Manual
P	Partial Treatment	SPM	Software Programmer's Manual
Y-XXX	Complete but in other manuals	SAM	Software Analyst's Manual
P-XXX	Partial Treatment in other manuals	RN	Release Notes
DATB	Documentation Accompanying BRAWLER		
MSM	Management Summary Manual		

5.1.2 Completeness of Software Programmer's Manual

The BRAWLER SPM has much of the information required for a standard SPM, but much information also needs to be developed. Some information of the standard SPM can be copied from the existing BRAWLER Version 6.14 SPM; therefore, some reformatting and content additions will be required. The most serious deficiencies are the lack of an

adequate description of error detection and diagnostic features, module descriptions, high-level and detailed call hierarchies, a dictionary of variables, and the discussion of global variables (common blocks). Table 5-3 shows completeness for each standard SPM section.

TABLE 5-3. Contents Summary of SPM for BRAWLER.

Software Programmer's Manual	Complete
Title Page and Preliminary Information	Y
1.1 Identification	Y-RN
1.2 System Overview	P- SUM, SPM, SAM, MSM
1.3 Document Overview	P
2.0 Referenced Documents	Y
3.1 Equipment Configuration	Y- SUM, MSM
3.2 Operational Information	P- SPM, MSM
3.3 Compiling and Linking Instructions	Y- SPM, DATB
4.1 Introduction to Programming Information	P
4.2 Call Hierarchy	N
4.3 Dictionary of Variables	N
4.4 Global Variables	P
4.5 Program, Subroutine, and Function Descriptions	P
4.6 Error Detection and Diagnostic Features	P
5.0 Terms and Abbreviations	Y
Appendix A: Detailed Call Hierarchy	N

Notes:

N	Not Included
Y	Included and Complete
P	Partial Treatment
Y-XXX	Complete but in other manuals
P-XXX	Partial Treatment in other manuals
DATB	Documentation Accompanying BRAWLER
MSM	Management Summary Manual
SUM	Software Analyst's Manual
SPM	Software Programmer's Manual
SAM	Software Analyst's Manual
RN	Release Notes

5.1.3 Completeness of Software Analyst's Manual

The BRAWLER SAM has much of the information required for a standard SAM; however, most of the existing functional implementation methodology information is not detailed enough for a standard SAM. Existing information needs to be reformatted and expanded upon. The most serious deficiencies are the lack of adequate detail in equation and algorithm description, subfunction input and output, and detailed assumptions and limitations. Table 5-4 shows the completeness for each SAM section.

TABLE 5-4. Contents Summary of SAM for BRAWLER.

Software Analyst's Manual	Complete
Title Page and Preliminary Information	P
1.1 Identification	P-RN
1.2 System Overview	P- SPM, SAM
1.3 Document Overview	P
2.0 Referenced Documents	Y
3.1 Functional Description Overview	Y
3.2.1 Assumptions and Limitations	P- SUM, SAM, MSM
3.2.2 Descriptions of Overall Methodology	P- SAM, MSM
3.3 Detailed Functional Implementation Methodology a.Equations and Algorithms b.Equations for Variables c.Inputs and Outputs d.Module Correlation with Functionality e.Impact on Model Results	 P- SUM, SPM, SAM N P P Y
4.0 Terms and Abbreviations	Y
Appendix A: Detailed Assumptions and Limitations	P- SUM, SAM, MSM

Notes:

Y	Included and Complete	SUM	Software Analyst's Manual
P	Partial Treatment	SPM	Software Programmer's Manual
N	Not Included	MSM	Management Summary Manual
Y-XXX	Complete but in other manuals	SAM	Software Analyst's Manual
P-XXX	Partial Treatment in other Manuals	RN	Release Notes

5.2 COMPLIANCE WITH DOCUMENTATION STANDARDS

This section presents BRAWLER documentation standards and documentation compliance discussions for accomplishing these standards. Information related to the SUM, SPM, and SAM was assessed for compliance using the standards summarized in the following sections. Details of this assessment are presented below.

5.2.1 Software User's Manual

The purpose of the SUM is to provide information and instructions enabling the user to execute a model. It should describe the execution steps, the expected output, and necessary actions when error messages appear. The SUM also provides an introduction to the model. The SUM facilitates the capability to operate the model correctly and to obtain the background for a deeper understanding of the model. The model should be described at a high-level using summarized theoretical information.

5.2.1.1 Standards

The recommended format and contents for a SUM are described in [Ref. 7] and repeated below:

Title Page and Preliminary Information. A SUM Title Page should include the following information: Model Name, Version Number, Volume Number (if applicable), Development Agency, Contractor Name and Address, Contract and CDRL Numbers (if applicable), Date Published, Distribution and Destruction Notices (if applicable), and Document Control Number (DCN). The term "Prepared by" should preface the listing of the Contractor Name and Address. In addition to the Title Page, a Foreword (Abstract), Table of Contents, List of Tables, and List of Figures should also be provided.

SECTION 1: INTRODUCTION

1.1 Identification. Identify the exact model title, its acronym or abbreviation, the version number, and any other official model identification information.

1.2 System Overview. State the purpose of the model. Include its mission, a general description of the physical systems simulated, and a general description of the intended scenarios. Provide overviews of all major modes of operation and scenarios corresponding to each mode. Auxiliary programs used to generate input data or process output data should be acknowledged; such auxiliary software should be detailed in Section 3.3 (entitled "Links to Other Programs").

1.3 Document Overview. List and describe the purpose of each section of the SUM. Also identify any other documents in the document set containing the SUM.

SECTION 2: REFERENCED DOCUMENT

List the title, number, author, publisher, date and classification level (unless all are unclassified) for each document used in generating the SUM, and for all known documentation for this model. Include sources for all documents not available through normal government stocking activities.

SECTION 3: EXECUTION PROCEDURES

Present detailed procedures necessary to run the model. The instruction set should be comprehensible by a user unfamiliar with the software design. Each subsection in this section should describe step-by-step instructions for executing the model, including details of the options available to the user at each step.

3.1 Initialization. Describe the initialization procedures necessary to execute the model. Detail all initialization options.

3.2 User Inputs. Describe user inputs at the file or data set level. Include variable name, format, allowable ranges, units of measure, and definition of each input item.

3.3 Links to Other Programs. Detail model relationships with pre- and post-processors. Describe drivers not considered part of the model, but part of the delivered model package. Discuss any other program with a link to a model.

3.4 Outputs. Detail the expected outputs from the model. This includes narrative reports as well as files. When applicable, give filenames with paths, data format and units of measure.

SECTION 4: ERROR MESSAGES

List each possible error message with a detailed explanation of each message. Provide a definitive course of action for each error message, including instructions for restarting the model.

SECTION 5: NOTES

5.1 Glossary of Terms

5.2 Abbreviations

APPENDICES. Appendices may be used for ease in document maintenance or for readability of the core text material. Examples of appendix contents are graphs, sample user interface printouts, and any classified information.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS

Appendix A is reserved for describing all model assumptions and limitations. These should be organized by major areas of functionality.

5.2.1.2 Assessment

This section contains recommendations for satisfaction of the SUM requirements described in Table 5-2. The BRAWLER Version 6.15 SUM draft publication (hereafter referred to as the current SUM) was found to provide a lot of required information, but much work remains to achieve all requirements for a standard SUM. Some of the contents for a standard SUM can be copied directly from the current SUM. Information present in manuals other than the current SUM (including the OLD) and information missing from the manual set will be mentioned in the assessment below as appropriate. Preliminary discussion about the current SUM and the OLD will be helpful in understanding generalized recommendations provided below.

The applicability of all current SUM sections to BRAWLER Version 6.15 is not apparent based on footnotes printed on most pages at the bottom-right corner. Individual sections seem to have been updated for different model releases based on the reference to Versions 5.1, 6.0, 6.13, 6.15, and 6.2 in the footnotes. Cross-reference mismatches indicates the need for a comprehensive review of the applicability of all information in the current SUM to Version 6.15. An example of the document configuration control problem is on Page 3.3-1 and 3.3-3 which apparently were written for Version 6.13. List item #3 refers to Figure 3.3.2.2-1 and item #5 refers to Figure 3.3.2.4-2; although, no such figures are in the SUM. Also, Page 3.3.2.3-2 has the footnote “Printed August 25, 1992-TBV6.13,” which indicates applicability to Version 6.13. Page 3.3.2.3-3 has the footnote “Printed November 8, 1991-TBV-6.0,” indicating applicability to Version 6.0. The latter page has a missing figure and has the annotation “Figure 3.3.2.3-2 goes here,” indicating that the figure has been missing for several editions of the SUM.

All of the on-line documentation seems to have originated from the current SUM. However, not all of the SUM is included in OLD. The OLD has a mixture of Version 6.15 and 6.2 SUM Sections 1, 2, 5, and most of 3. SUM Version 6.15 Sections 1, 2, and 5 are present in the OLD, while SUM Version 6.2 Sections 3 and the last two subsections of Section 5 have superseded those of SUM Version 6.15.

In addition, numerous errors are in the OLD feature. These primarily are related to missing or erroneous hypertext links, or to incorrect section references. Several OLD cross-reference problems applicable to Version 6.15 are from Sections 3.2.5, 3.2.6, and 3.3.3.2. Several tables and figures are unreferenced, which results in their inaccessibility due to no hypertext link. Also, in the OLD several figures containing “railroad format charts” have partially or totally unreadable text. An implied recommendation for the OLD is that it should be thoroughly reviewed and revised to ensure that it is complete, cross-referenceable (including through hypertext links), and applicable to Version 6.15.

Of course, the information applicable to Version 6.2 should be utilized for that version. Similarly, an implied recommendation for the entire current SUM is that it should be

thoroughly reviewed and revised to ensure that it is complete, cross-referenceable, and applicable to Version 6.15.

Title Page and Preliminary Information. The current SAM has the required Title Page information, but needs to have a "Prepared by" phrase preceding the Contractor Name and Address. The "abstract" portion (Item 13) of Standard Form 298 immediately following the Title Page is a duplicate of that from the SPM which should be corrected to reflect the purpose of the SUM. The corrected abstract should be moved to the standard SUM Foreword.

1.0 INTRODUCTION

1.1 Identification. Release Notes (RN) [Ref. 5] has the model identification in Section 2.0 "Version Identification." This should be copied to Section 1.1 of a standard SUM. BRAWLER is the full name of the model and is not an abbreviation.

1.2 System Overview. System overview information is contained in the current SUM, Section 2.1.2 "Physical System Highlights" and 2.1.3 "Model Applicability." These sections are not subdivided into descriptions of various systems. However, the Management Summary Manual (MSM) also has a good system overview in Sections 2.1 "Capabilities" and 2.2 "Hardware Systems Modeled" and the MSM overview is subdivided by high-level modeling areas. Those MSM sections should be used to structure the standard SUM, Section 1.2 in which the current SPM, Sections 2.1.1, 2.1.2, and 2.1.3 "Simulation Processing Overview" should be incorporated except for redundant information. Major modes of operation with their associated scenarios do not seem to be applicable to the overall model; however, the individual systems modeled can be set to various modes through user inputs. If model-level modes of operation really exist, they should be described in the standard SUM, Section 1.2. Intended scenarios are not explicitly stated, although they are inferred throughout the functional descriptions of the current SAM starting at Section 2.0. Intended scenarios need to be reviewed in standard SUM, Section 1.2. The high-level discussion of two pre-processors and three post-processors in the current SPM, Section 2.1.4 should be included in standard SUM, Section 1.2. System overview information is contained in OLD menu item #1, Introduction to BRAWLER.

1.3 Document Overview. Section 1.3 of the current SUM "Organization" contains a description of the purpose of each section in the manual; yet the appendices need to be briefly referenced. A listing of all BRAWLER documentation distributed with the model also needs to be added.

2.0 REFERENCED DOCUMENTS

Current SUM, Appendix B is a bibliography that should be moved to standard SAM, Section 2.0. It should be reviewed for completeness.

3.0 EXECUTION PROCEDURES

3.1 Initialization. *Documentation Accompanying BRAWLER, Version 6.15* [Ref. 4], Section 6.5 "Loading and Running" and its subsections contains instructions on executing BRAWLER as delivered (including sample files). Current SUM, Section 5.2 "Running BRAWLER" should be included with this [Ref. 4] section which all

should be moved to standard SUM, Section 3.1. Initialization instructions are in OLD menu item #3, Setup and Execution of Run.

3.2 User Inputs. The current SUM, Section 5.0 is called "TBMAIN Setup and Execution." This section and all of its subsections describe high-level inputs associated with creating a scenario and defining desired outputs. For example, the checkpoint/restart feature allows the state of a BRAWLER run to be saved at user-specified simulation times. Another example is a diagnostic print feature that allows the user to specify output from subroutines or groups of routines for purposes of investigating anomalous model operation. All of Section 5.0 of the current SUM should be moved to standard SUM, Section 3.2 except for Section 5.2 which should be moved to Section 3.1. The Section 5 information is provided at OLD menu item #3.

A detailed discussion of user inputs is covered in current SUM, Section 3.0 "BRAWLER Input Data" and all of its subsections. Section 3.1 "General Description" is a good introduction to all of the input files. All files can be changed by the user, although some may not require user modification. For example, data specific to a well-characterized aircraft probably will never need to be changed.

Section 3.0 and its subsections contain several hundred pages of input file specifications. Also, the majority of the OLD is devoted to explaining user input data in menu item #2, Creating Input Data. The level of information ranges from introductory paragraphs to detailed data format descriptions. The verbal introductions generally are good. Detailed descriptions of input file formats include the specific location within a file for a variable name, its format, and a comments column. A typical comments column entry has a definition of the variable, unit of measure, and allowable range of values. However, many comment entries do not include unit of measure and allowable range of values. All input file format descriptions should be reviewed and modified as necessary to include the variable name, format, allowable ranges, units of measure, and definition of each input item.

3.3 Links To Other Programs. The current SPM, Section 2.1.4 "Other BRAWLER Programs" lists and briefly describes two pre-processors and three post-processors. That same section has a good pictorial of the relationship of BRAWLER to those processors (see Figure 2.1-1 entitled "Data Flow in BRAWLER and Its Peripheral Processors"). The current SUM, Section 5.0 "Preprocessing" and its subsections detail the pre-processing methods in BRAWLER. The current SUM, Section 6.0 "Post-processing" and its subsections detail post-processing methods in BRAWLER. These two sections and SPM, Section 2.1.4 should be moved to standard SUM, Section 3.3. Also any other software packages required to utilize all BRAWLER associated features should be mentioned. For example, the FrameViewer® software is required to run the on-line documentation feature (beginning with BRAWLER Version 6.2).

3.4 Outputs. The current SUM, Section 4.0 is called "BRAWLER Output Data." Section 4.1 "Overview of Output Data" introduces the output files generated during a model run (excludes post-processing description). Section 4.2 "Detailed Description" provides more detailed descriptions of the output files. Good narrative descriptions of the file contents are followed by "detailed" descriptions of items and

sample output files. The descriptions of items in the output files are general and do not include file paths, data formats, and units of measure. For example, page 4.2.3-2 cites the description of the "Pg 19" portion of the diagnostic output file as "This page displays the status of the communications jamming in the engagement." This particular example does not provide an adequate description of output data for the purpose of a standard SUM. Furthermore, the sample did not have page labels corresponding to the description of the items in the file. One could infer the available details from a sample output file given enough time to search through thirteen pages in the sample. The current SUM, Section 4.2 should be revised to provide applicable filenames with paths, data formats, and units of measure for all detailed output description. It should be moved to the standard SUM, Section 3.4. Output generated by post-processing methods is described in the current SUM, Section 8.0 "Model Utilities." The same inconsistencies in the types of information also apply to Section 4.2; thus the current SUM, Section 8.0 and its subsections should also be revised to provide applicable filenames with paths, data formats, and units of measure for all detailed output description and should be moved to the standard SUM, Section 3.4.

4.0 ERROR MESSAGES

Section 7.0 of the current SUM is titled "Trouble-shooting Guide." It contains an alphabetical list of error messages that may occur during the initialization of data from the various data sets. The conditions causing the error and the routine involved is explained in most error descriptions, yet a definitive course of action for each error message generally is not provided. A suggested course of action often is "contact a programmer," which is inadequate for purposes of a standard SUM. Section 7.0 of the current SPM is titled "Error Messages"; however, specific error messages and diagnostics are not mentioned. Rather one- or two-sentence descriptions of error checking subprograms is provided. Detailed descriptions of each error message (more than just the provided messages for data initialization errors) and a course of action for each should be written for the standard SUM, Section 4.0 (including instructions for restarting the program).

5.0 TERMS AND ABBREVIATIONS.

A glossary of terms and abbreviations is combined in the current SPM, Appendix A. These should be separated into a glossary of terms in the standard SUM, Section 5.1 and a list of abbreviations in Section 5.2.

APPENDIX A. DETAILED ASSUMPTIONS AND LIMITATIONS.

Current SUM, Section 2.3 "Assumptions and Limitations" is a three-page high-level discussion of system-related assumptions and limitations, limitations on model parameters, and output limitations. The current SAM, Section 2.4 "Assumptions and Limitations" is a one-page high-level discussion of stochastic processes used in BRAWLER. The MS [Ref. 6], Section 2.5 also has a high-level discussion of assumptions and limitations. These high-level discussions should be used to identify detailed assumptions and limitations. All high-level assumptions and limitations should be included in the standard SAM, Section 3.2.1. Both high-level and detailed discussions of assumptions and limitations are scattered throughout the current SAM. A detailed comprehensive discussion of assumptions and limitations should be

included in Appendix A of the standard SUM (same as Appendix A in the standard SAM).

Other Appendices. The current SUM, Appendices C and D are useful cross-references for conditionally-printed diagnostics. These can remain as standard SUM appendices. The current SUM, Appendix E is a detailed description of the General Dynamics (GD) Infrared (IR) Model and this should be moved to standard SAM, Section 3.3.

5.2.2 Software Programmer's Manual

The purpose of the SPM is to enable a user or programmer to understand the operation of a model; install, maintain, and modify it; and convert it for use on other computer systems. The SPM addresses the software implementation of the model rather than theoretical considerations and it provides a guide to the internal workings of the software. It includes information on compiling and linking the code as well as descriptions of hardware and software requirements and peculiarities. If hardware or software listed in a SPM is commercially available, its existing documentation should be referenced by document title and number and the manufacturer should be cited.

5.2.2.1 Standards

The recommended format for a SPM is described in [Ref. 8] and repeated below:

Title Page and Preliminary Information. The SPM Title Page should include the following information: Model Name, Version Number, Volume Number (if applicable), Development Agency, Contractor Name and Address, Contract and CDRL Numbers (if applicable), Date Published, Distribution and Destruction Notices (if applicable), and Document Control Number (DCN). The term "Prepared by" should precede the listing of the Contractor Name and Address. In addition to the Title Page, sections covering a Foreword (Abstract), Table of Contents, List of Tables, and List of Figures should also be provided.

SECTION 1: INTRODUCTION

1.1 Identification. Identify the exact model title, its acronym or abbreviation, the version number, and any other official model identification information.

1.2 System Overview. State the purpose of the model. Include its mission, a general description of the physical systems simulated, and a general description of the intended scenarios. Provide overviews of all major modes of operation and scenarios corresponding to each mode. Auxiliary programs used to generate input data or process output data should be acknowledged and described.

1.3 Document Overview. List and describe the purpose of each section of the SPM. Also identify any other documents in the document set containing the SPM.

SECTION 2: REFERENCED DOCUMENTS

List the title, number, author, publisher, date, and classification level (unless all are unclassified) for each document used in generating the SPM and for all known documentation for this model. Include sources for all documents not available through normal government stocking activities.

SECTION 3: PROGRAMMING ENVIRONMENT

3.1 Equipment Configuration. Describe the computing devices and operating systems that the model operates on and under (developmental and target environment). List other software

required for model execution. An example of a software requirement is a graphical user interface (GUI).

3.2 Operational Information. Describe hardware/operating system characteristics and capabilities required for the model. This includes details such as storage space for the source code with a complete input set, memory requirements with utilization examples, memory protection features and input/output (I/O) characteristics.

3.3 Compiling and Linking Instructions. Present instructions on compiling and linking the model software, and describe equipment needed for such procedures. Detail applicable names and version numbers of equipment or software.

SECTION 4: PROGRAMMING INFORMATION

4.1 Introduction. Describe in general the applicable programming conventions and style used to develop the model. A short development history emphasizing programming style and convention evolution could be helpful for mature models with a diverse history.

4.2 Call Hierarchy. Present a top-level subroutine call tree. It should branch down only as far as the main routines for each major area of functionality. A comprehensive call hierarchy (probably generated by an automated software tool) should be included in Appendix A.

4.3 Dictionary of Variables. List all variables alphabetically and provide a definition of each (with units of measure). State whether each variable is global or local. If global, give the name of the common block containing it. If local, list the module(s) containing it.

4.4 Global Variables. Global variables are contained in common blocks for programs written in FORTRAN and are called external variables for programs written in C. Other programming languages will have their own conventions for the handling of global variables. Using the convention appropriate to the programming language, list these variables alphabetically. For example, the common blocks from FORTRAN programs should be listed alphabetically. For each block, list the variables contained in it, give a general description of these variables, and list the modules in which it appears. For programs written in other languages, just list the variables alphabetically, give a general description of these variables, and list the modules in which they appear.

4.5 Program, Subroutine, and Function Descriptions. Provide detailed information about each program, subroutine, or function (hereafter called “module”). List modules alphabetically. Library functions should be listed but only briefly described. All other module descriptions should contain the following information in a clear, concise format useful to a programmer tasked with maintaining the model.

a. Give a brief narrative description of the module. Its objective and method for fulfilling the objective should be stated.

b. Give its location in a specified file, its call sequence, security classification level, and size (number of lines of executable code).

c. Provide a list of calls made by the module and calls to the module.

d. Alphabetically list all variables used by the module. For each variable, list its dimension, type, usage as input and/or output, engineering units, a very brief description, and its usage as an argument, local, or common variable. The user can refer to the Dictionary of Variables (Section 4.3) for a detailed description.

e. Detailed Description. Elaborate on the objectives and methods used to fulfill the objectives stated in the brief description in list item “a” above. Provide a reference in the SAM if a theoretical discussion related to the modeled processes is provided.

4.6 Error Detection and Diagnostic Features. Describe model error diagnostics. Provide a table listing each error condition, the routine(s) in which it is utilized, the model variable(s) involved, and the conditions (logic) causing the error. These diagnostics also are summarized in the SUM, Section 4.

SECTION 5: NOTES

5.1 Glossary of Terms

5.2 Abbreviations

Appendices. Appendices may be used for ease in document maintenance or for readability of the core text material. Examples of appendix contents are subroutine call tree, flow diagrams, sample user interface printouts and any classified information.

APPENDIX A: DETAILED CALL HIERARCHY

Present the complete calling hierarchy in this appendix.

5.2.2.2 Assessment

The SPM for Version 6.15 was not produced, but the model developer (DSA, Inc.) distributed the SPM for Version 6.14 for use in assessment of Version 6.15 documents. The SPM for Version 6.14 is divided into two separate volumes. One volume has the majority of the included programming information; however, it is not identified as the first of two separate volumes. The "second volume" is supposed to contain Appendices C through K; yet, these were not produced for Version 6.14. The most recent appendices are in Volume 1A for Version 5.0 dated June 1988. The SPM is <u>not</u> on the SURVIAC list of documentation for BRAWLER even though the list is stated as the "full set of documentation." Implicit in the assessment of this section is the recommendation of applicable updating of current documentation to correctly describe Version 6.15.

The most recently published SPM documentation [Ref. 2], referred to as the current SPM hereafter, is evaluated below for completeness and compliance with the standard SPM requirements since much of the existing information will be applicable to Version 6.15. Other useful information was extracted from References 4 and 5. The current SPM satisfies many of the requirements for a standard SPM. Most of the topics included are described in adequate detail, but many topics have not been addressed. The following paragraphs contain comments regarding the SPM requirements described in Table 5-3.

Title Page and Preliminary Information. The SPM evaluated for this report has the required information, but needs to have a "Prepared by" phrase preceding the Contractor Name and Address. The "abstract" portion (Item 13) of Standard Form 298 immediately following the Title Page will suffice as a Foreword for a standard SPM.

1.0 INTRODUCTION

1.1 Identification. The Release Notes [Ref. 5] has the model identification in Section 2.0 "Version Identification." This should be copied to Section 1.1 of a standard SPM.

1.2 System Overview. System overview information is contained in the current SUM, Section 2.1.2 "Physical System Highlights" and 2.1.3 "Model Applicability." These sections are not subdivided into descriptions of various systems. However,

the MSM also has a good system overview in Sections 2.1 "Capabilities" and 2.2 "Hardware Systems Modeled" and its overview is subdivided by high-level modeling areas. Those MSM sections should be used to structure the standard SPM, Section 1.2. The current SUM, Sections 2.1.2 and 2.1.3 should be incorporated except for redundant information. Major modes of operation with their associated scenarios do not seem to be applicable to the overall model; yet, the individual systems modeled can be set to various modes through user inputs. If model-level modes of operation really exist, they should be described in the standard SPM, Section 1.2. Intended scenarios are not explicitly stated; although, they are inferred throughout the functional descriptions of the current SAM starting at Section 2.0. Intended scenarios need to be reviewed in standard SPM, Section 1.2. The high-level discussion of two pre-processors and three post-processors in the current SPM, Section 2.1.4 should be included in standard SPM, Section 1.2.

1.3 Document Overview. Section 1.0 and the first three paragraphs of Section 1.2 of the current SPM "Introduction to the Programmer Manual" contain a description of the writing convention of the manual; yet, the purpose of each section in the manual is not provided. A listing of the distributed document set is in the first paragraph of that section; although, it does not include the SPM [Ref. 2] in that list. A description of the purpose of each section to the second level of subdivision (i.e., Sections 5.4, 5.5, etc.) of the SPM needs to be developed for inclusion into standard SPM, Section 1.3. Also, the SPM [Ref. 2] needs to be added to the list of available documentation.

2.0 REFERENCED DOCUMENTS.

The list of referenced documents is in current SPM, Appendix B. It should be reviewed for completeness and moved to standard SPM, Section 2.0

3.0 PROGRAMMING ENVIRONMENT

3.1 Equipment Configuration. Host computer systems and additional software required to exercise the full model capability are described in Section 2.1.1 "Model Identification" of the current SUM. It states that BRAWLER has been hosted on machines manufactured by Digital (VAX), IBM, Honeywell (Multics), Gould, SUN (UNIX), CDC, and Masscomp (UNIX). That section should be moved to standard SPM, Section 3.1. The equipment model versions or series for each manufacturer is described in the first two paragraphs of MSM [Ref. 6], Section 3.3.1 "Computer Resources, Speed, and Memory Requirements." Those paragraphs should be moved to standard SPM, Section 3.1. A proprietary software development environment is used for BRAWLER on-going development and it is mentioned in the first two paragraphs of *Documentation Accompanying BRAWLER Version 6.15* [Ref. 4], Section 3.2 "System Software Requirements." Those paragraphs should be moved to a standard SPM, Section 3.1 and the reader should be referred to *DSA ENVIRONMENT©Development Environment User's Manual* [Ref. 7] for more information about that proprietary package.

3.2 Operational Information. Disk storage requirements for the distributed software are described in Section 3.1 of Reference 4 which should be moved to the standard SPM, Section 3.2. A description of input and output disk storage

requirements for sample scenarios should also be developed for inclusion in the standard SPM, Section 3.2. Memory requirements are described in the final two paragraphs of MSM [Ref. 6], Section 3.3.1 "Computer Resources, Speed, and Memory Requirements." These should be moved to standard SPM, Section 3.2. Examples of the amount of user time and computer time needed to run BRAWLER are provided in MSM [Ref. 6], Section 3.3.2 "Time Required for a Study Effort." This section also should be moved to standard SPM, Section 3.2.

3.3 Compiling and Linking Instructions. The final paragraph of Reference 4, Section 3.2 "System Software Requirements" describes the hardware and software required to compile and link BRAWLER. Descriptions of the distribution tape format is provided in Reference 4, Sections 4.0, 4.1, and 4.2. The same reference has installation, compiling, and linking instructions for the complete model in Section 6.0 and its subsections, and instructions for an upgrade (changes to the former version) in Section 7.0 and its subsections. All of the Reference 4 sections mentioned above should be moved to a standard SPM, Section 3.3. Procedures for first-time initialization of the Measures of Performance Database is provided in the current SPM, Section 6.5.6, and file modifications necessary (before compiling and linking) to add new user variables is provided in Section 6.6. These sections should be moved to standard SPM, Section 3.3.

Installation, compiling, and linking instructions need to be tailored as necessary for the operating systems and platforms specified as supporting TAC BRAWLER. Some users have older systems than those used by the developer, and are subject to installation errors while using instructions for newer systems.

4.0 PROGRAMMING INFORMATION

Preliminary statements about Sections 2.2 through 3.1 of the current SPM will be helpful in understanding the recommended parsing of information between several standard manuals. Those sections have the majority of programming details about systems modeled in BRAWLER. Each second-level section (i.e., 2.4, 2.5, etc.) is titled as a major system. Three example titles are Radar, Communications, and Pilot Model. At the system level a brief introductory paragraph is provided and sometimes "data structures" are provided. The "structure" essentially is a list of COMMON blocks that contain data associated with the processes and equipment of the modeled system.

Each major section is subdivided by subfunctions of the system. High-level descriptions of subfunctions are followed by call hierarchies that implement each subfunction and sometimes a separate call tree is provided for data initialization. Modules that implement each subfunction are listed and described briefly. Descriptions of the series of events modeled by the subfunction are provided. A few flow diagrams are provided to describe modules and processes, but the diagrams are notional and do not represent complete descriptions of the modeled subject.

The types of information mentioned in the former two paragraphs are not all included for each subfunction and different levels of detail of information apply to the same information category for different subfunctions. For example, descriptions of modules usually are a single sentence, although some have descriptions of one or

more paragraphs. Even though the system descriptions are not written in uniform detail and format, the paragraphical descriptions of modeled processes, data structures, module descriptions, and call hierarchies are easily distinguishable categories. As such, these categories will be referred to in the recommendations below rather than a specification of paragraph modifications needed for each category for each system.

4.1 Introduction. The current SPM, Section 8.1 and its subsections describe the programming style and conventions used in the development of BRAWLER. That section should be moved to Section 4.1 of a standard SPM. No description of an evolution of the conventions is provided. If the conventions have changed over the model history, a short developmental history emphasizing programming style and convention evolution also should be added to standard SPM, Section 4.1.

A high-level discussion of the directory environment structure is introduced in the final two paragraphs of the current SPM, Section 1.2,while Section 2.1.3 provides high-level descriptions of initialization and data management aspects of the program structure. These should be moved to the standard SPM, Section 4.1.

Section 9.2 of the current SPM mentions that the concept of utilities grouped together as a package has become pervasive in BRAWLER. This "concept" is a programming style that has resulted in specific programming methods used to accomplish a variety of tasks in an efficient manner. Sections 2.1.1, 2.1.2, and 9.2.1 through 9.2.10 of the current SPM provide good concise overviews of some of the methods. These sections should be moved to Section 4.1 of the standard SPM and new overviews should also be added for methods not mentioned in the current SPM.

The methods mentioned in the former paragraph are detailed in all sections included from Section 3.2 to 4.2.5. For readability, these details should be grouped as Appendix B of a standard SPM.

Programming methods have been developed to efficiently pre-process data before use by model algorithms. The methods are detailed in the current SPM, Sections 5.0 through 5.5. An identification and brief description of the methods should be written for standard SPM, Section 4.1 and the current SPM, Sections 5.0, 5.1, 5.2, 5.3, and 5.5 should be moved to Appendix C of a standard SPM. Section 5.4 should be deleted since that section states "This program is not currently maintained." Non-operational code portions (and associated documentation) should not be included in a model release.

Programming methods have been developed to efficiently post-process model intermediate calculations and output data. The methods are detailed in the current SPM, Sections 6.0 through 6.2.3 and Sections 6.2.5 through 6.5.5. An identification and brief description of the methods should be written for standard SPM, Section 4.1 and the above-mentioned current SPM section should be moved to standard SPM, Appendix D. Section 6.2.4 is a detailed mathematical description of several aspects of scenario graphical representation which should be moved to Section 3.3 of the standard SAM.

4.2 Call Hierarchy. Directory structures for code portions related to subfunctions are often provided in the current SPM. A directory structure is similar in appearance to a module call hierarchy; however, different levels in a directory environment generally do not indicate the sequence of module calls. Directory structure description is not an explicit requirement for a standard manual; thus, if knowledge of directory structure is necessary or useful for understanding program structure, it should be included as a separate appendix.

Call hierarchies specialized to modules that implement a specific subfunction are presented in most of the subfunction descriptions. Each hierarchy is depicted through increased indentation of lower-level modules from the left page margin. A brief description is included for each listed module. The brief descriptions should be copied to the beginning of the module descriptions of standard SPM, Section 4.5. The existing specialized hierarchies should be moved to standard SAM, Section 3.3 since these help identify the module correlation with functionality. A high-level call hierarchy with its lowest levels indicating main routines that implement subfunctions should be developed for inclusion in standard SPM, Section 4.2. A Unix script file (included in the DSA_ENVIRONMENT software) is available to find all subroutines called by a user-specified subject subroutine. The program mains can be used as the subject module of the script, and successive application of the script can be used to identify the high-level call hierarchy.

4.3 Dictionary of Variables. An alphabetical listing of common variables and the modules that utilize the variables is not provided in the current documentation. However, an alphabetical listing of common variables and the "Include" files that utilize the variables is provided at Appendix J of the current SPM which is useful for itemizing a subset of all BRAWLER code variables. A complete alphabetical list of the variables contained in all program modules and include files needs to be developed according to the standards. This task can be partially automated through a DSA script file that identifies the common block in which a subject global variable is declared. The standard SPM, Section 4.3 should contain the list with variable definitions.

4.4 Global Variables. Global variables are contained in common blocks for programs written in the ANSI-Standard FORTRAN language. Appendix G of the current SPM provides an alphabetical listing of each common block and the modules that use it. This list should be copied to standard SPM, Section 4.4 and for each common block the name and brief description of each variable in the common block should be written. This task also can be partially automated through a DSA script file that identifies the common block in which a subject global variable is declared. Appendix J of the current SPM provides an alphabetical listing each common variable and the "Include" files that use it. Appendix J is a good reference for identifying include files names which should be added to the list of modules that use the common variable.

4.5 Program, Subroutine, and Function Descriptions. Each BRAWLER module needs to have detailed information as described in the following paragraphs. Current SPM subfunction descriptions list and briefly describe modules that implement the subfunction. However, routines that perform utility tasks that are used by many subfunctions have been given special attention in Section 9.1 through 9.1.17

of the current SPM. The call sequence is given for each module and good concise descriptions of the methods used to fulfill the modeling objectives are provided. In any case, for those described modules, the brief description should be the basis for a statement of the module objective in standard SPM, Section 4.5. Descriptions of all program subroutines should be developed according to the SPM standards shown in Section 5.2.2.1 and in Figure 5-1.

For each module that is part of a larger file, the name of the file and the module location within the file needs to be included in standard SPM Section 4.5. The module's call sequence, classification level, and number of lines of executable code also should be stated.

Appendix F of the current SPM alphabetically lists each BRAWLER module and the names of modules which call it. Appendix H of the current SPM alphabetically lists each BRAWLER module and the names of modules that it calls. Based on these two appendices for each module, the calls made by it and to it should be included in standard SPM, Section 4.5.

Appendix H of the current SPM lists all common blocks used by each BRAWLER module. However, not all common variables in a given common block need to be used by a given module. Only those common variables utilized by the module processes should be itemized along with local variables and module arguments if applicable. For each variable, list its type, dimension, usage as input and/or output, engineering units, a very brief description, and its usage as an argument, local, or common variable.

Specific programming methods used to accomplish subfunction objectives are provided in the current SPM. However, specific programming methods used to accomplish module objectives are not provided in the current SPM except for the utility routines of Section 9.1 through 9.1.17 which should be moved to standard SPM, Section 4.5. For other modules, a description of the programming methodology used to fulfill the module objectives needs to be written.

FUNCTION NAME: AddHeight

1. Brief Description: This function will add a scalar height to a vector.
2. Calling Sequence: AddHeight (&OpFac -> Position, (double) ComSub -> AntHeight, &ComSub -> Antenna);
3. Security Classification: Unclassified
4. Program Size: 40 lines (21 executable lines)
5. Location: File ANTENNA.C, Line 662
6. Calling Environment

   Calls: none
   Called By: SetAntenna

7. External Variables: UnitVector(Position, NewPosition)
8. Internal Variables:

Name	Usage	Dim	I/O	Type	Definition	Units
Position	loc	1	I	Vector	current antenna position	m
Height	loc	1	I	Scalar (real-double precision)	scalar height to add to the antenna position	m
NewPosition	loc	1	O	Vector	new antenna position	m
X	arg	1	---	Real	X component	m
Y	arg	1	---	Real	Y component	m
Z	arg	1	---	Real	Z component	m

9. Discussion and Formulation:

The current position vector of the antenna is stored in Position, while the new position vector of the antenna is in NewPosition. The X, Y, and Z components of the new antenna position are calculated as follows:

$$X_{NEW} = (X_{NEW} \times HEIGHT) + X_{OLD}$$

$$Y_{NEW} = (Y_{NEW} \times HEIGHT) + y_{OLD}$$

$$Z_{NEW} = (z_{NEW} \times HEIGHT) + z_{OLD}$$

FIGURE 5-1. Example of Summary Subroutine Description.

4.6 Error Detection and Diagnostic Features. Section 7.0 of the current SUM is titled “Trouble-shooting Guide.” It contains an alphabetical list of error messages that may occur during the initialization of data from the various data sets. The conditions causing the error and the routine involved is explained in most error descriptions, but the code variables involved are not provided. Section 7.0 of the current SPM is titled “Error Messages.” However, specific error messages and diagnostics are not mentioned; rather, one- or two-sentence descriptions of error checking subprograms are provided. Detailed descriptions of each error, the

module(s) in which the error occurred, the code variables involved with the error, and conditions causing the error should be included in standard SPM, Section 4.6. These diagnostics should be detailed, programming-related explanations of those briefed in standard SUM, Section 4.0.

5.0 TERMS AND ABBREVIATIONS

A glossary and abbreviation list is combined in the current SPM, Appendix A. These should be separated into a glossary of terms at standard SPM, Section 5.1 and a list and identification of abbreviations in Section 5.2.

APPENDIX A: DETAILED CALL HIERARCHY

A detailed call hierarchy should be developed for standard SPM, Appendix A.

Other Appendices. The "second volume" of the current SPM is supposed to contain Appendices C through K, but these were not produced for Version 6.14. The most recent appendices are found in Volume 1A for Version 5.0 dated June 1988. These are cross-reference lists, each of which is indexed by a different programming feature. One example is Appendix G which lists each common block name with the names of all subroutines that use it. While the indexed lists could be useful and probably are easy to generate by use of an automated tool, they are not required by a standard SPM and will not be included in the recommendations of Section 5.3 of this document. However, the standards allow for inclusion of material in appendices that are useful for understanding the core document subject matter. Thus, cross-reference appendices may be included after Appendix A (call hierarchy) if they are applicable to BRAWLER Version 6.15.

5.2.3 Software Analyst's Manual

The purpose of the SAM is to describe the functional structure and algorithms of a model. It should describe the purpose and background of the model in general terms and give detailed technical descriptions of its complete capabilities, structure, and functions. These detailed descriptions should divide the capabilities of the model into the major functions it performs. All equations, algorithms, and decision processes used by each major function should be described in detail. Details also should be given about model assumptions, limitations, and flexibility (e.g., ability to address different types of problems). Inputs and outputs should be described in words rather than file formats. Each module should be described in great detail to explain the correlation between the modules and model functional descriptions. The SAM enables the user to understand the theoretical basis of the model. The user needs it to facilitate understanding of the code and to ensure that the model is appropriate for particular analysis requirements.

5.2.3.1 Standards

The recommended format for a SAM is described in [Ref. 8] and repeated below:

Title Page and Preliminary Information. The SAM Title Page should include the following information: Model Name, Version Number, Volume Number (if applicable), Development Agency, Contractor Name and Address, Contract and CDRL Numbers (if applicable), Date Published, Distribution and Destruction Notices (if applicable), and Document Control Number

(DCN). The term "Prepared by" should precede the listing of the Contractor Name and Address. In addition to the Title Page, sections covering a Foreword (Abstract), Table of Contents, List of Tables, and List of Figures should also be provided.

SECTION 1: SCOPE

1.1 Identification. Identify the exact model title, its acronym or abbreviation, the version number, and any other official model identification information.

1.2 System Overview. State the purpose of the model. Include its mission, a general description of the physical systems simulated, and a general description of the intended scenarios. Discuss the types of problems addressed and types of answers provided by the model. Provide overviews of all major modes of operation and scenarios corresponding to each mode. Auxiliary programs used to generate input data or process output data should be acknowledged and described.

1.3 Document Overview. List and describe the purpose of each section of the SAM. Also identify any other documents in the document set containing the SAM.

SECTION 2: REFERENCED DOCUMENTS

List the title, number, author, publisher, date, and classification level (unless all are unclassified) for each document used in generating the SAM and for all known documentation for this model. Include sources for all documents not available through normal government stocking activities.

SECTION 3: FUNCTIONAL DESCRIPTION

3.1 Overview. Describe the model's complete functionality without reference to implementation methodology. These descriptions should elaborate on the overall mission and major modes described above in System Overview (Section 1.2). Descriptions should be presented in the order functional methodologies are described in the sections that follow.

3.2 General Modeling Approach

3.2.1 Assumptions and Limitations. Describe high-level assumptions and limitations of overall model functionality.

3.2.2 Overall Modeling Methodology. Explain how assumptions, limitations, and the processes involved influence the general modeling methodology.

3.3 Detailed Functional Implementation Methodology. Describe how the capabilities of the model are functionally implemented. Divide this section into subsections corresponding to the model's major areas of functionality; provide the following information for each subsection:

a. Equations and Algorithms. Provide detailed technical descriptions and purposes for use of specific empirical and analytic equations, numerical algorithms, and decision processes used by the function. Use flow diagrams to depict the implemented logic and use illustrations to depict geometrical considerations when appropriate. Justify use of specific probability distributions. When trade-off studies for equation usage were performed, justify use of the chosen equation.

b. Equations for Variables. Present and describe all equations (using mathematical notation) used for calculating variables that are significant in the implementation of the functionality. Indicate the code variable names that correspond with the variables described by these equations.

c. Model Inputs and Outputs. Inputs and outputs relevant to a particular area of functionality should be described in words without reference to code

implementation details. Identify the relationship of inputs to the equations and algorithms in one of those areas.

d. Code Module Correlation with Functionality. Identify each module used to implement an area of functionality and describe the processes contained in that module. The description of each module should include its purpose and a detailed technical explanation. Correlate these processes with the model functional descriptions. Applicable library functions may simply be listed with a short description.

e. Impact on Model Results. Describe the impact of the functionality on model results.

SECTION 4: NOTES

4.1 Glossary of Terms.

4.2 Abbreviations.

Appendices. Appendices may be used for ease in document maintenance, examples and illustrations to assist in understanding model capabilities, or for readability of the core text material. Examples of appendix contents are logic flow diagrams, sample user interface printouts, examples of post-processor use, former studies published using this model, and any classified appendices.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS

Appendix A is reserved for describing all model assumptions and limitations. These should be organized by major areas of functionality. This appendix is the same as Appendix A of the SUM.

5.2.3.2 Assessment

The current SAM for BRAWLER [Ref. 3] contains much information about the modeled processes, but in general does not have the level of detail required for a complete standard SAM. Most of the included discussions are good introductions to the modeled processes and can be copied to subsections of the standard SAM and elaborated upon.

Preliminary statements about the current SAM detailed methodology sections (Section 2.2 and greater) will be helpful in understanding the recommended parsing of information between overview- and detailed-level sections of a standard SAM.

The current SAM has discussion of major areas of functionality subdivided by subfunctions. For each subfunction, high-level descriptions are typically presented without mathematical details. However, many equations are scattered among the numerous subfunction descriptions. Also, many subfunction descriptions have applicable assumptions and limitations stated. Those descriptions that have equations are presumed to be more complete than subfunctions that do not have equations. Of course, the existence of equations does not necessarily indicate that a full mathematical explanation is provided.

Deficiencies identified in the current SAM are based on standard SAM requirements. An implied recommendation for categories of information assessed as missing is that the information needs to be developed for inclusion in a standard SAM. A complete standard SAM will require the developer to identify all modeled functionalities not currently described, and provide all details identified in Section 3.3 of the standard SAM. The details

for each functionality should be made adequate for the level of fidelity of the modeled functionality.

The assessment that follows is based primarily on information as currently documented in the SAM and supplemented by model implementation aspects described in the current SPM. The descriptions in the current SPM of modeled processes for subfunctions are excellent as a basis for detailed implementation methodology descriptions in Section 3.3 of a standard SAM. The following paragraphs contain comments regarding the SAM requirements described in Table 5-4.

Title Page and Preliminary Information. The current SAM has the required Title Page information, but it needs to have a "Prepared by" phrase preceding the Contractor Name and Address. The "abstract" portion (Item 13) of Standard Form 298 immediately following the Title Page is a duplicate of that from the SPM which should be corrected to reflect the purpose of the SAM. The corrected abstract should be moved to the standard SAM Foreword.

1.0 SCOPE

1.1 Identification. The RN [Ref. 5] has the model identification in Section 2.0 "Version Identification." This should be copied to Section 1.1 of a standard SAM.

1.2 System Overview. Section 2.1 of the current SAM is titled "Overview" and provides good general descriptions of the mission, physical systems simulated, and intended model scenarios. However, a discussion on the types of problems addressed and the types of answers provided by the model is missing and should be developed. A high-level discussion of the off-line post-processing tools is described in current SPM, Section 2.1.4 "Other BRAWLER Programs." All of the above material should be included in standard SAM, Section 1.2.

1.3 Document Overview. Section 1.3 of the current SAM titled "Organization" describes the purpose of each of its sections. This should be included in Section 1.3 of a standard SAM after being updated to describe the purpose of each standard SAM section. All documents available to a BRAWLER user should be cited in standard SAM, Section 1.3.

2.0 REFERENCED DOCUMENTS

Current SAM, Appendix B is a bibliography that should be moved to standard SAM, Section 2.0. It should be reviewed for completeness.

3.0 FUNCTIONAL DESCRIPTION

Functional descriptions of BRAWLER modeled processes are primarily in Section 2.2 and 2.3 of the current SAM. These two sections are subdivided by major areas of functionality such as aircraft performance modeling (Section 2.2.1), weapon modeling (Section 2.2.2), and radar (Section 2.2.3). Major areas are further subdivided by subfunctions which have discussions at a level of detail applicable to one or both of subfunction overviews and subfunction detailed methodology. Detailed methodology also is provided in several appendices of the current SAM.

The level of detail in the subfunction descriptions is not uniform. Therefore, the assessment below indicates those sections that contain overview information applicable to standard SAM, Section 3.1 and those with detailed methodology information for Section 3.3. Standard SAM, Section 3.2 will also utilize some information from current SAM, Sections 2.2 and 2.3 as well as from other sources as described below.

3.1 Overview. Sections 2.2 and 2.3 of the current SAM have overviews of major areas of functionality that should be used in standard SAM, Section 3.1. Some of the sections also have detailed information. The sections with overview information in general will not be copied in total; rather, the overviews will be extracted from the existing information and the included detailed information will need to be moved to standard SAM, Section 3.3. For example, numerous equations are interspersed throughout Sections 2.2 and 2.3; equations and algorithms are the first items called for in standard SAM, Section 3.3; overview information needs to be moved to the standard SAM Section 3.1; and the remainder of information (which is presumed to be more detailed) from those sections should be included in standard SAM, Section 3.3.

3.2 General Modeling Approach

3.2.1 Assumptions and Limitations. Current SAM, Section 2.4 "Assumptions and Limitations" is a one-page high-level discussion of stochastic processes used in BRAWLER. Current SUM, Section 2.3 "Assumptions and Limitations" is a three-page high-level discussion of system-related assumptions and limitations, limitations on model parameters, and output limitations. The MSM [Ref. 6], Section 2.5 also has a high-level discussion of assumptions and limitations. All high-level assumptions and limitations should be included in standard SAM, Section 3.2.1. Both high-level and detailed discussions of assumptions and limitations are scattered throughout the current SAM. A detailed comprehensive discussion of assumptions and limitations should be included in Appendix A of the standard SAM (same as Appendix A in the standard SUM).

3.2.2 Overall Modeling Methodology. A section explaining how assumptions, limitations, and the processes involved influence the general modeling methodology should be generated for standard SAM, Section 3.2.2. Also, the MSM, Section 2.5 has a short discussion of the influence of some assumptions and limitations on general modeling methodology which should be used to identify some aspects of modeling methodology. The current SAM, Section 2.5 is titled "Model Flexibility" and discusses how the general modeling methodology of processes involved in BRAWLER results in a model easily upgradable with user-defined systems. That section should be moved to standard SAM Section 3.2.2.

3.3 Detailed Functional Implementation Methodology. As mentioned earlier, Sections 2.2 and 2.3 of the current SAM have overview information and detailed functional implementation information. The sections with detailed information for standard SAM, Section 3.3 in general will not be copied in total; rather, the detailed functionality descriptions will be extracted from the existing information and the included overview information will need to be moved to standard SAM, Section 3.1.

Detailed methodology descriptions for a standard SAM contain several subjects which are listed below. The subjects are treated with different levels of detail throughout the applicable current SAM sections.

a. **Equations and Algorithms**. The current SAM, Sections 2.2 and 2.3 have much of the information appropriate for detailed description of the functional flow of processes involved with subfunctions. The descriptions, in general, describe phenomena in words rather than in mathematical notation which is good as introductory information. Some descriptions are well supplemented with mathematical detail. However, in general, most subfunctions will need to be described in greater detail through comprehensive identification and description by the developer of all empirical and analytic equations. This includes justification of chosen probability distributions.

The current SPM has descriptions of the series of events for modeled subfunctions. The descriptions are well-suited to representation using a flow diagram, but flow diagrams do not accompany the descriptions. A few flow diagrams are provided to describe modules and processes; yet the diagrams are notional and do not represent complete descriptions of the modeled subject. The SPM descriptions of subfunction implementation should be considered as a basis for functional flow diagrams that will need to be developed for subfunction algorithms; of course, applicable current SAM descriptions should be incorporated into flow diagram discussions.

Current SPM, Section 6.2.4 explains in detail the equations and algorithms associated with graphical representation of the model scenario and that section should be moved to standard SAM, Section 3.3.

The General Dynamics (GD) Infrared (IR) model that has been incorporated in BRAWLER is described in adequate detail for use in the SAM. The GD report is in current SUM, Appendix E. Section 2.0 "Model Description," pg. 1 through 22 of that report, should be moved to Section 3.3 of the standard SAM.

b. **Equations for Variables.** Descriptions are not provided for equations for code variables used to store calculations of subfunction algorithms. These descriptions should be included in SAM, Section 3.3.

c. **Model Inputs and Outputs.** Input to and output from subfunctions are not explicitly stated. The level of discussion in the current SAM often is not detailed enough to identify exact input and output. For example, discussion of target projected area calculation (Section 2.2.11.4.2) is focused enough to easily infer input and output, but the description of input and output is not apparent in the description of the flight tactics decision (Section 2.3.1.3). Tables detailing the relationship of inputs and outputs to each area of functionality should be developed for inclusion in standard SAM, Section 3.3. The SPM cites common blocks associated with subfunctions which is a starting point to identify applicable input and output.

d. **Code Module Correlation with Functionality.** Call hierarchies specialized to modules implementing specific subfunctions are included with many of the subfunction descriptions in the current SPM. The hierarchies are good indicators of applicable modules and their interrelationships. The hierarchy is not required for this

section of a standard SAM; yet it is an excellent way of identifying modules. However, detailed description of module processes and how they implement the intended functionality is not provided with the module identifications. The descriptions should be developed for all modules for each subfunction which should be included in standard SAM, Section 3.3.

e. **Impact on Model Results.** The effects that particular areas of functionality have on model results is often inferred in current SAM subfunction discussion, but not explicitly stated. The impact should clearly specified in standard SAM, Section 3.3.

4.0 TERMS AND ABBREVIATIONS

A glossary and definition of abbreviations is in current SAM, Appendix A. This information should be divided into a glossary of terms and an identification of abbreviations in standard SAM, Sections 4.1 and 4.2, respectively.

APPENDIX A: DETAILED ASSUMPTIONS AND LIMITATIONS

The current SUM, Section 2.3 "Assumptions and Limitations" is a three-page high-level discussion of system-related assumptions and limitations, limitations on model parameters, and output limitations. The current SAM, Section 2.4 "Assumptions and Limitations" is a one-page high-level discussion of stochastic processes used in BRAWLER. The MSM [Ref. 6], Section 2.5 also has a high-level discussion of assumptions and limitations. These high-level discussions should be used to identify detailed assumptions and limitations. All high-level assumptions and limitations should be included in standard SAM, Section 3.2.1. Both high-level and detailed discussions of assumptions and limitations are scattered throughout the current SAM. A detailed comprehensive discussion of assumptions and limitations should be included in Appendix A of the standard SUM (same as Appendix A in the standard SAM).

5.3 RECOMMENDED MODIFICATIONS

The sections that follow describe the changes needed to bring documentation applicable to BRAWLER Version 6.15 into compliance with the standards recommended in [Ref. 8]. Table entries provide estimates of the number of additional pages (based on the current manuals page count) needed to complete such recommendations. Comments are also included in these tables regarding what recommendations are being made. These estimates are a rough order of magnitude based on the current understanding of BRAWLER documentation. Wherever possible, the page estimates are based on treatments of similar topics in the documentation or in the documentation of other models.

5.3.1 Software User's Manual

The current SUM is very close to fulfilling all the requirements for a standard SUM. Table 5-5 presents a summary of the recommendations from the above discussions to achieve SUM compliance with the proposed documentation standards.

TABLE 5-5. Estimated Number of New Pages for BRAWLER SUM.

Section/Topic	Number of New Pages	Recommendations
Title Page and Preliminary Information	0	Move abstract from SF 298 to standard SUM, Foreword with corrections.
1.1 Identification	0	Move from RN, Section 2.0.
1.2 System Overview	0	Move from MSM, SUM, and SPM. Extract intended scenarios from SAM, Section 2.0.
1.3 Document Overview	0	Move from SUM, Section 1.3.
2.0 Referenced Documents	0	Move from SUM, Appendix B.
3.1 Initialization	0	Move from SUM, Section 5.2 and DATB, Section 6.5.
3.2 User Inputs	5	Move from SUM, Sections 3.0 and 5.0. Add units of measure and allowable ranges.
3.3 Links to Other Programs	0	Move from SUM, Sections 5.0 and 6.0 and SPM, Section 2.1.4.
3.4 Outputs	10	Move from SUM, Sections 4.0, 4.1, 4.2, and 8.0. Update with file paths, data formats, units of measure.
4.0 Error Messages/Actions	E/4	Move from SUM, Section 7.0 and SPM, Section 8.0. Add detailed error message/action descriptions. Most of this section will be new (E = # error messages not described).
5.0 Terms and Abbreviations	0	Move from current SUM, Appendix A.
Appendix A: Detailed Assumptions and Limitations	F/10	Base on SUM. Section 2.3; MSM, Section 2.5; SAM, Section 2.4 (F = # of assumptions and limitations not mentioned).
Other Appendices	0	Move SUM, Appendix E to SAM, Section 3.3.

Future upgrading of the on-line documentation (OLD) needs to include a comprehensive review of model version applicability, and a review of all cross references. The OLD uses cross-referencing through titles of sections, but not by section numbers. Numerous section numbers referenced in the OLD text result in cross-reference errors, since the new OLD format uses only textual section identification. These errors also apply to figures and tables, which all need to be cross-referenced by title. The OLD cross-referencing is accomplished through hypertext links. Several links have not been implemented, which results in some figures and tables not being accessible. The section, title, and figure cross-references should be thoroughly reviewed to ensure that hypertext links exist and are correct. Furthermore, text included in some figures is unreadable due to low resolution (even after enlarging on the screen); the text in figures should be modified as necessary to be easily readable.

5.3.2 Software Programmer's Manual

Information missing from the current SPM includes description of a high-level and detailed module call hierarchy, dictionary of variables, error detection and diagnostic features, and module descriptions. The current SPM needs a significant amount of modification to meet the requirements for a standard SPM. Table 5-6 presents a summary of the recommendations from the above discussions to bring the SPM into compliance with the proposed documentation standards.

TABLE 5-6. Estimated Number of New Pages for BRAWLER SPM.

Section/Topic	Number of New Pages	Recommendations
Title Page and Preliminary Information	0	Move abstract from SF 298 to standard SPM, Foreword.
1.1 Identification	0	Move from Release Notes, Section 2.0.
1.2 System Overview	1	Structure based on MSM, Sections 2.1 and 2.2. Move from current SUM, Section 2.1.2 and SPM, Section 2.1.4. Discuss intended scenarios based on SAM, Section 2.0.
1.3 Document Overview	1	Move from SPM, Section 1.0 and 1.2. Detail the purpose of each section. Add discussion of Documentation Set.
2.0 Referenced Documents	0	Move from SPM, Appendix B.
3.1 Equipment Configuration	0	Move from SUM, Section 2.1.1 and MSM, Section 3.3.1.
3.2 Operational Information	1	Move from SPM, Section 3.2. Write discussion of model run data requirements. Move disk storage requirements from MSM, Section 3.1. Move memory requirements discussion from MSM, Sections 3.3.1 and 3.3.2.
3.3 Compiling and Linking Instructions	0	Move from SPM, Sections 6.5.6 and 6.6. Move from DATB, Sections 3.2, 4.0, 4.1, 4.2, 6.0, and 7.0.
4.1 Introduction of Programming Information	3	Extract from Sections 1.2, 2.1.1-2.1.3, 6.0-6.2.3, 6.2.5-6.5.5, 8.1, and 9.2.1-9.2.10. Add section on coding conventions/changes with short developmental history; write pre- and post-processing methods.
4.2 Call Hierarchy	3	Generate top-level hierarchy from scratch.
4.3 Dictionary of Variables	20	Develop a variable definition list.
4.4 Global Variables	30	Develop a common block definition list based on appendices.

TABLE 5-6. Estimated Number of New Pages for BRAWLER SPM. (Contd.)

Section/Topic	Number of New Pages	Recommendations
4.5 Program, Subroutine and Function Descriptions	N	Extract from Sections 9.1-9.1.17 and appendices of current SPM. Expand module descriptions (N = number of modules not described in Sections 9.1-9.1.17).
4.6 Error Detection and Diagnostic Features	n/2	Some are in Section 7.0. Identify associated variables (n =number of diagnostics not described).
5.0 Terms and Abbreviations	0	Move from current SPM, Appendix A.
Appendix A: Detailed Call Hierarchy	27	Create from scratch.
Other Appendices	0	Extract descriptions of "packages" and pre- and post-processing methods.

5.3.3 Software Analyst's Manual

The BRAWLER SAM has a considerable amount of good high-level discussion, but limited detailed discussions. A significant number of detailed methodology descriptions needs to be generated to fulfill all requirements for a standard SAM. Table 5-7 presents a summary of the recommendations from the above discussions to create a standard SAM.

TABLE 5-7. Estimated Number of New Pages for BRAWLER SAM.

Section/Topic	Number of New Pages	Recommendations
Title Page and Preliminary Information	0	Move abstract from SF 298 to standard SAM, Foreword with corrections.
1.1 Identification	0	Move from Release Notes, Section 2.0.
1.2 System Overview	2	Move from SAM, Section 2.1 and SPM Section 2.1.4. Discuss problems addressed and answers provided.
1.3 Document Overview	1	Base on SAM, Section 1.3.
2.0 Referenced Documents	0	Move SAM, Appendix B.
3.1 Functional Description Overview	0	Move from current SAM, Section 2.2 and 2.3.
3.2.1 Assumptions and Limitations	2	Mostly new. Some can be copied from Section 2.4 and scattered sections of SAM and from MSM, Section 2.5.
3.2.2 Overall Modeling Methodology	10	Mostly new. Some discussion in MSM, Section 2.5 and SAM, Section 2.5.
3.3 Detailed Functional Implementation Methodology		

TABLE 5-7. Estimated Number of New Pages for BRAWLER SAM. (Contd.)

Section/Topic	Number of New Pages	Recommendations
a. Equations and Algorithms	W/2	Move from SAM, Sections 2.2 and 2.3 and SPM, Section 6.2.4. Base flow diagrams on SPM descriptions. Move GD IR model description here (W = number algorithms not described).
b. Equations for Code Variables	X/2	Correlate with equations from SAM, Sections 2.2 and 2.3; SPM, Section 6.2.4; and GD IR model (X= number equations for variables).
c. Inputs and Outputs	Y/2	Develop tables for listing inputs and outputs to subfunctions (Y = number of subfunctions).
d. Module Correlation with Functionality	Z/2	Develop list of modules associated with functional areas and put them in tables with inputs and outputs (Z = number of modules associated with subfunction).
e. Impact on Model Results	0	Included with algorithm descriptions.
4.0 Terms and Abbreviations	0	Move from SAM Appendix A
Appendix A: Detailed Assumptions and Limitations	F/10	Base on SUM, Section 2.3; MSM, Section 2.5; SAM, Section 2.4 (F = # of assumptions and limitations not mentioned).

5.3.4 Summary

A significant level of effort will be required to generate three standard manuals as described in Section 5.2. The existing on-line documentation will only require a moderate effort to fix discrepancies; however, only a subset of the user's manual is included OLD. This effort would only require programming the corrections and verifying that cross referencing and version applicability are correct. On-line documentation is not a requirement for the standard documentation set, but a comprehensive and bug-free set of OLD could be useful to many users. A significant effort would be required to produce a full set of useful on-line documentation. Table 5-8 summarizes the estimated number of new pages required for each manual. In many cases, information from several separate sources must be appropriately merged into the manuals.

TABLE 5-8. Summary: Estimated Number of New Pages.

Manual	Additional Pages
SUM	15 + E/4 + F/10
SPM	86 + N + n/2
SAM	15 + W/2 + X/2 + Y/2 + Z/2
Total	116 + N + n/2 + W/2 + X/2 + Y/2 + Z/2

Notes:
E = # of error messages not described
F = # of assumptions and limitations not described

N = # of modules not described
n = # of error diagnostics
W = # of algorithms not described
X = number of equations for variables
Y = number of subfunctions
Z = # of modules associated with subfunction

The documentation for BRAWLER will require much work to fulfill the recommended standards. The missing information will require a fairly large number of new pages. The most serious deficiencies in the SUM are the lack of an adequate list of error messages, a comprehensive discussion of assumptions and limitations, and detailed file format descriptions. The most serious deficiencies in the SPM are the lack of an adequate description of error detection and diagnostic features, module descriptions, high-level and detailed call hierarchies, a dictionary of variables, and the discussion of global variables (common blocks). The most serious deficiencies in the SAM are the lack of adequate detail in equation and algorithm description, subfunction input and output, and detailed assumptions and limitations.

A lot of the new pages will contain subroutine, variable and common block descriptions, and error detection and diagnostics. These are not as technically demanding as the theoretical discussions in an SAM, but time to examine the code and write the descriptions will be required. The most significant effort required to fulfill the standard documentation requirements probably will be the comprehensive identification and description of the theory and implementation of modeled processes of BRAWLER.

Model documentation is worth a significant expenditure of resources. The Military Operations Research Society (MORS) has included good documentation as a step in the model validation process [Ref. 9]. Development and use of standard documentation will increase user efficiency as well as model credibility.

5.4 IMPLICATIONS FOR V&V

The quality of the current BRAWLER documentation is assessed to be good for the included information. Extensive reformatting will be needed to achieve standardization; yet, this does not greatly impact V&V activities. However, an important task to facilitate future V&V will be to provide the information that currently is missing from the documents. The deficiencies have been identified throughout this documentation assessment. The impact of the deficiencies will be described next.

A comprehensive discussion of assumptions and limitations is needed to completely describe theoretical considerations of the modeled processes; a complete V&V of design approaches used to model the intended processes may be hindered without identification of assumptions and limitations. Of course, the lack of adequate detail in equation and algorithm description also will hinder the V&V of design approach. Input and output of subfunctions of modeled systems is important to help identify unique modeled entities at a fairly detailed level; input, processing, and output are important aspects to consider when assessing a modeled process. Citing applicable references for design approaches is another important documentation requirement which helps facilitate complete equation and algorithm verification. The on-line documentation needs to have correct cross-referencing to be verified as being accurate.

Detailed file format descriptions, module descriptions, high-level and detailed call hierarchies, a dictionary of variables, and the discussion of global variables (common blocks) all are important to characterize the programming aspects of a simulation. These details are important to assess the code design to determine if the intended modeled processes are implemented in code correctly and are documented accurately.

5.5 IMPLICATIONS FOR MODEL USE

A model user could use a simulation incorrectly when information necessary to use the model is missing. For example, the absence of a discussion on assumptions and limitations could lead to improper program setup resulting in erroneous interpretation of output data. A prospective model user needs a complete set of documentation to assess whether specific portions of a candidate model are simulated at a level detailed enough for specific analysis requirements. BRAWLER documentation generally is not detailed enough to assess the fidelity its modeled subfunctions.

The lack of adequate model execution error diagnostics in the SUM and the SPM could hinder the timely correction of problems. The development of a document overview and the improved definition of the input file variables could help reduce new-user training efforts. However, given enough time, most of the deficiencies noted in this documentation assessment can be compensated for by a review of the code.